

RELATIONSHIP OF BROILER BRUISE AGE TO APPEARANCE AND TISSUE HISTOLOGICAL CHARACTERISTICS

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Primary Audience: Quality Assurance Personnel, Plant Managers, Live
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SUMMARY

Because commercial broilers may be bruised at any time during production and even up to the time of slaughter, minimizing bruising requires a clear understanding of when and how it occurs. The present study was conducted to investigate the relationship between the age, visual appearance, and histological characteristics of a bruise. Market-aged broilers were anesthetized, bruised on the breast, wing, and drum, and processed 0, 1, 6, 12, or 24 hr after receiving the bruises. Bruise color measurements revealed that as their age increased, breast bruises became darker (higher ΔL ; change in lightness value), whereas wing and drum bruises became lighter (lower ΔL). Redness and yellowness of breast bruises were not significantly different at any of the bruise ages. With increasing bruise age, wing bruises became less red and less yellow, and drum bruises became more red and more yellow. Histological tissue samples showed that drum bruises were more severe than breast or wing bruises at all time intervals. For all bruises, maximum ΔL and tissue edema occurred in carcasses of broilers injured 6 hr before processing.

Key words: Broiler bruising, carcass quality, defects, discoloration, downgrading

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DESCRIPTION OF PROBLEM

Of the graded broiler carcasses processed in 1997, over 40% were downgraded due to carcass quality problems. Approximately 25% of the carcass downgrades resulted from

bruising that occurred at various stages of production, with the majority of the bruises appearing on the wing (36%), drum (27%), and breast (19%) [1]. During processing, downgraded carcasses are usually salvaged by removing defects and sending the undamaged

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portion of the carcass to cut-up and further processing. However, the salvage operation decreases plant yield, efficiency, and productivity from that involved in processing whole carcasses [2]. It has been estimated that carcass downgrading costs the broiler industry more than \$300 million in lost sales each year [2], and this loss is generally accepted as an inevitable feature of production and processing practices.

Although carcass bruising is one of the most costly downgrading factors for the poultry industry, it has received little attention over the last 30 yr. Hamdy *et al.* [3] suggested that if the age of a bruise on a carcass (bruise age) could be determined, then a means would be available for identifying when the animal received the bruise. Knowing the bruise age would permit investigation of where and how the bruise occurred, and this information could be used by companies to provide incentives and develop programs for improving carcass quality [3]. Hamdy *et al.* [3] developed a chemical test to determine the approximate age of a bruise in livestock to within 1/2 to 1 day based upon bilirubin and biliverdin levels in damaged tissue; high tissue bilirubin (yellow) and biliverdin (green) are indicative of hemoglobin degradation and tissue healing. However, when broilers were bruised 2 min or 12, 24, 36, 48, 72, 96, or 120 hr before processing, bruises that occurred within 12 hr of each other could not be chemically distinguished [4]. According to Hamdy *et al.* [4], approximately 90% of all bruises on broilers occur within the last 12 hr that the birds are alive, which suggests that the majority of the bruises are received during catching, loading, unloading, hanging, and stunning. Thus, it would seem that the bilirubin tissue analyses would not differentiate when most bruises originate. These same authors suggested that although the bilirubin tissue analyses were not specific enough to determine bruise age, bruise age could be estimated by appearance [4].

McCausland and Dougherty [5] reported that the age of bruises in lambs and calves could be determined using microscopic analyses to observe changes in tissue cell populations. They found that bruises that occurred at the instant before slaughter had moderate tissue hemorrhage, and few neutrophils and macrophages. Conversely, bruises that occurred 8 hr before death had extensive tissue

hemorrhage, fragmented muscle fibers, and many neutrophils, but few macrophages. Muscle hemorrhage for bruises that occurred 24 hr before death was similar to that of bruises that occurred 8 hr before death; however, 24-hr bruises differed from 8-hr bruises in having neutrophils and macrophages closely associated with the damaged fibers [5]. McCausland and Dougherty [5] suggested that microscopic analyses of bruised tissue could serve as a guide for aging bruises; however, this method is too time-consuming to be practical for industry use. The objective of the present study was thus to develop a practical guide for determining the age of poultry bruises by providing standards for comparison using visual images, objective bruise color measurements, and microscopic analyses.

MATERIALS AND METHODS

BIRDS AND BRUISING

In each of two replications, 35-day-old commercial male broilers ($n = 30$ per replication) were obtained from a local grower, cooped, transported to the university facility, and placed into a floor pen on pine shavings. At 41 days of age, broilers were individually examined for bruises, and birds appearing to be bruise free were separated into four groups and anesthetized using an intramuscular injection of Ketaset (35 mg ketamine/kg body weight) [6]. Ketaset was selected to produce a dissociative anesthesia of short duration with minimal influences on muscle tone and heart and respiratory rates. After the anesthetic had taken effect, broilers were bruised at the appropriate time at three locations on the left side on the breast, wing, and drum. Bruising was performed using a consistent force of 4.1 kg for each blow delivered by a contusion apparatus developed by Hamdy *et al.* [7]. Broilers were processed at 42 days of age using simulated commercial conditions 0, 1, 6, 12, or 24 hr after receiving their bruises. Bruise free control broilers were anesthetized with each group, at the time of bruising, and processed at the same time as the bruised broilers.

PROCESSING

Prior to processing, feed was withdrawn from broilers for 10 hr. During the first 4 hr of the withdrawal period, the birds were in pens with access to water; during the remaining

6 hr, the birds were in coops. Cooped broilers were transported less than 1 km to the USDA pilot processing plant, where they were electrically stunned head to shanks in a brine stunner with voltage set at 50 V alternating current for 10 sec, and a current of approximately 33 mA. Stunned broilers were transferred to restraining cones and bled for 90 sec by severing both carotid arteries and at least one jugular vein. Broilers were scalded at 54.4°C for 45 sec, mechanically defeathered for 30 sec, and manually eviscerated.

COLOR MEASUREMENTS AND HISTOLOGICAL STAINING

The C.I.E. [8] L^* , a^* , and b^* color values were measured with skin intact on bruised areas of carcasses before carcass chilling using a Minolta colorimeter [9]. The colorimeter was standardized using a white ceramic tile [10]. For each carcass within a bruise age group, three color readings were measured per carcass part ($n = 18$ readings per part and bruise age group). Differences in color values (ΔL , Δa , Δb) were calculated by subtracting the L^* , a^* , and b^* values for bruised tissue from the L^* , a^* , and b^* values for the control carcasses [11].

Within 15 min after slaughter, skin and underlying bruised tissue were carefully excised from carcasses and fixed in a 10% buffered formalin solution. Samples were dehydrated in graded alcohols, embedded in paraffin, and histologically stained; representative areas were digitized. Histopathological evaluations were made for each traumatized site at each bruise age. Parameters evaluated and scored were free red blood cells, edema (proteinaceous fluid), and muscle degeneration/necrosis.

STATISTICAL ANALYSIS

The entire experiment was replicated twice with 18 birds in each replication (three birds per treatment). Three color readings were taken on each bruised area (breast, wing, or drum) per carcass for a total of 108 measurements. The three readings for each bruised area were averaged ($n = 36$) to give one reading for each breast, wing, and drum per carcass at each treatment time (control, 0, 1, 6, 12, or 24 hr). Color difference (ΔL , Δa , Δb) was calculated from the average color values and analyzed using the General Linear

Model procedure of SAS [12]. The main factors tested were bruise age and replication, using the interaction between these two factors as the error term.

RESULTS AND DISCUSSION

A bruise has been defined as a superficial injury resulting from an impact force where the skin is not pierced, but the cells and capillaries beneath the skin are ruptured in the damaged areas [13, 14]. Consequently, bruises have a distinct appearance from blood accumulation in perivascular tissue. Figure 1 shows the change in lightness (ΔL) for breast, wing, and drum bruises on 42-day-old broilers processed at various bruise ages. Bruise age had a significant effect ($P < .05$) on the ΔL values for breast and wing bruises, with marginal influence on drum bruises (Table 1; $P = .059$). Overall, breast bruises became darker with increasing bruise age, whereas wing and drum bruises became lighter with increasing bruise age. The ΔL values for all bruises reached a maximum at a bruise age of 6 hr, indicating that the 6-hr bruises were darker in color than the other aged bruises (Figure 1). L values for bruised wings were found to vary widely, ranging from $L^* = 52.3$ for control wings to $L^* = 39.2$ for 6-hr bruised wings. This variation may be due to the proximity of the wing veins to the skin surface, and the variety of light and dark areas naturally occurring in the wing region of the bird. These same factors may have also contributed to the variation in wing ΔL between replications (Table 1). Additionally, the interaction between bruise age and replication was found to have a significant effect on wing and drum ΔL . This may be related to variation in tissue damage within muscles that are in close proximity to bone.

Figure 2 shows the change in redness (Δa) for breast, wing, and drum bruises on 42-day-old broilers processed at various bruise ages. Bruise age had no effect on the Δa values for breast bruises, and these Δa values were not significantly different from the Δa values for the control carcasses (Table 1). This was not the case for the Δa values for wing and drum bruises, which were significantly affected by bruise age. Redness of bruised wings was significantly affected by bruise age and replication, but not by the interaction between the two (Table 1). With the exception of the

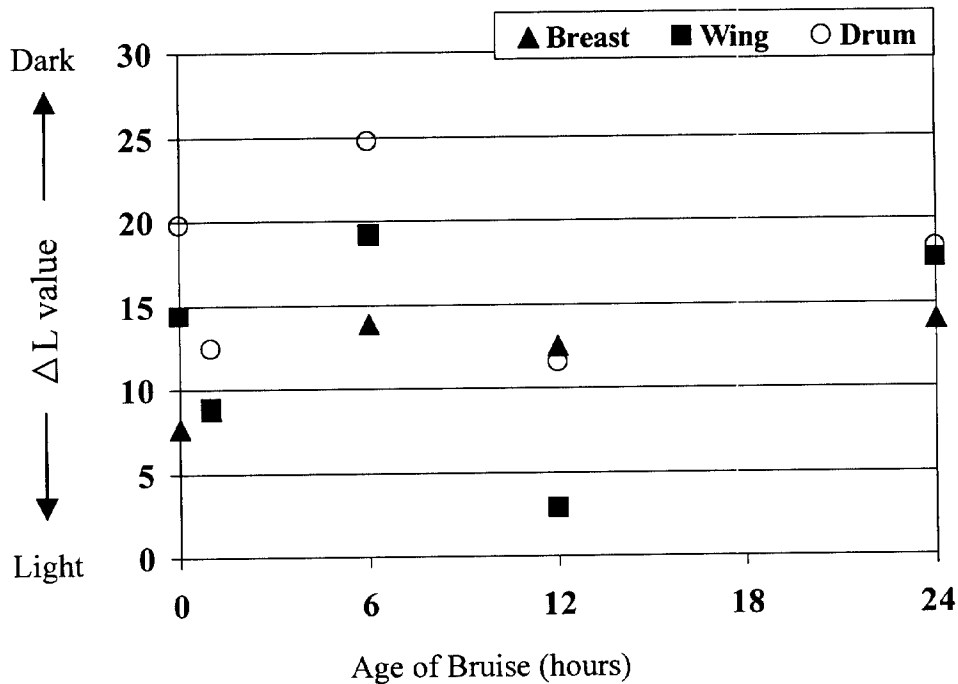


FIGURE 1. Change in lightness (ΔL) for breast, wing, and drum bruises on broilers processed at various times (bruise age) after receiving the bruises

bruises at a bruise age of 1 hr, wing bruises were less red in color than the control wings, but all of the wings (bruised and control) had comparable redness. Redness of bruised drums increased with age, and values were greatest for broilers processed 1 and 24 hr after receiving the bruise. Redness of drum bruises was not affected by replication or by bruise age \times replication interaction. As with the redness color parameter, yellowness of breast bruises was not affected by bruise age, and these values were not significantly different from the yellowness measured on the control carcasses (Figure 3). Yellowness of breast bruises was affected by the interaction

between bruise age and replication, and this significance may be explained by flock differences (genetic or diet). Wing bruises became less yellow as the bruise age increased. Overall, drum bruises did not vary in yellowness with bruise age; however, maximum drum bruise yellowness occurred on the carcasses of broilers processed 1 hr after receiving the bruise (Figure 3).

Changes in the appearance of broiler bruises with increasing bruise age showed the same trend as those measured objectively (Figures 4 and 5). Hamdy *et al.* [4] reported visible changes in broiler bruises at bruise ages of 2 min and 12, 24, 36, 48, 72, 96, and

TABLE 1. Probability results from statistical analyses of color differences (ΔL , Δa , Δb)^A for broiler carcass bruises occurring at 0 to 24 hr before processing

	BREAST			WING			DRUM		
	ΔL	Δa	Δb	ΔL	Δa	Δb	ΔL	Δa	Δb
Bruise age ^B	0.0109	0.6769	0.6769	0.0064	0.0006	0.0001	0.0667	0.0266	0.5624
Replication	0.3058	0.0434	0.3205	0.0015	0.0001	0.0001	0.3007	0.1591	0.1279
Bruise age \times Replication	0.0589	0.0005	0.0005	0.0002	0.0565	0.0199	0.0186	0.1272	0.5292

^A ΔL refers to the change in lightness (control minus bruise); Δa refers to the change in redness (control minus bruise); Δb refers to the change in yellowness (control minus bruise).

^BBruise age corresponds to recovery time before processing of 0, 1, 6, 12, or 24 hr.

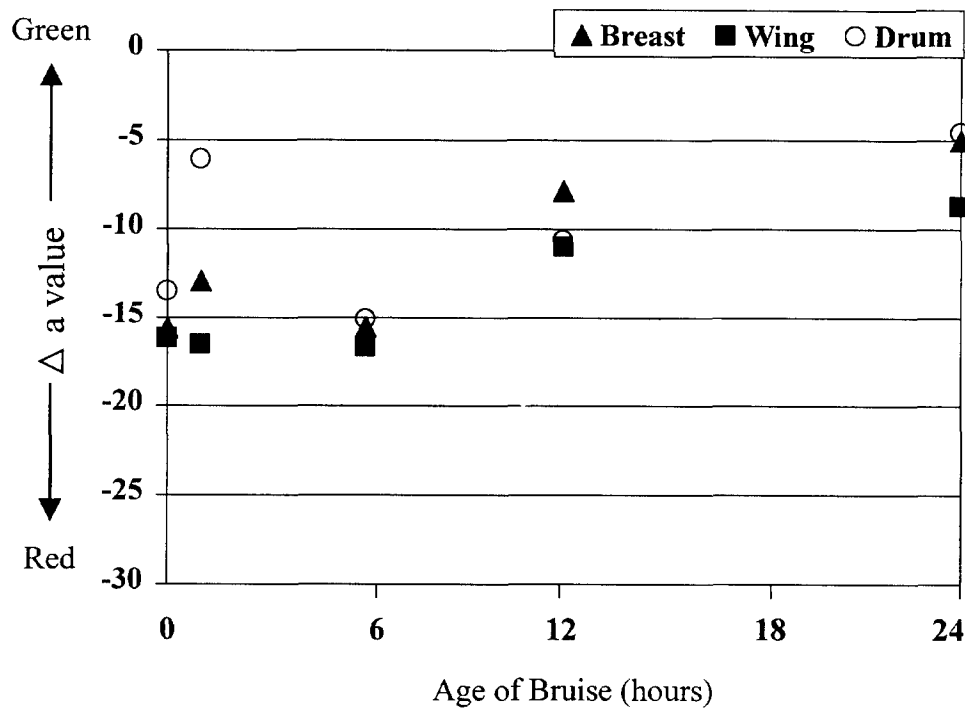


FIGURE 2. Change in redness (Δa) for breast, wing, and drum bruises on broilers processed at various times (bruise age) after receiving the bruises

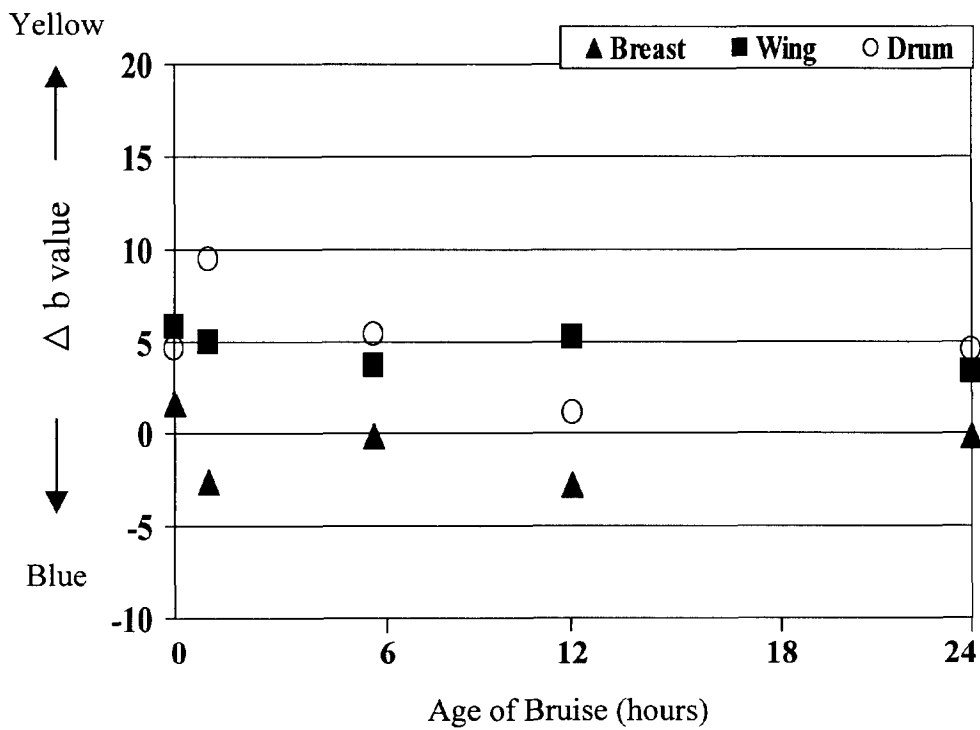


FIGURE 3. Change in yellowness (Δb) for breast, wing, and drum bruises on broilers processed at various times (bruise age) after receiving the bruises

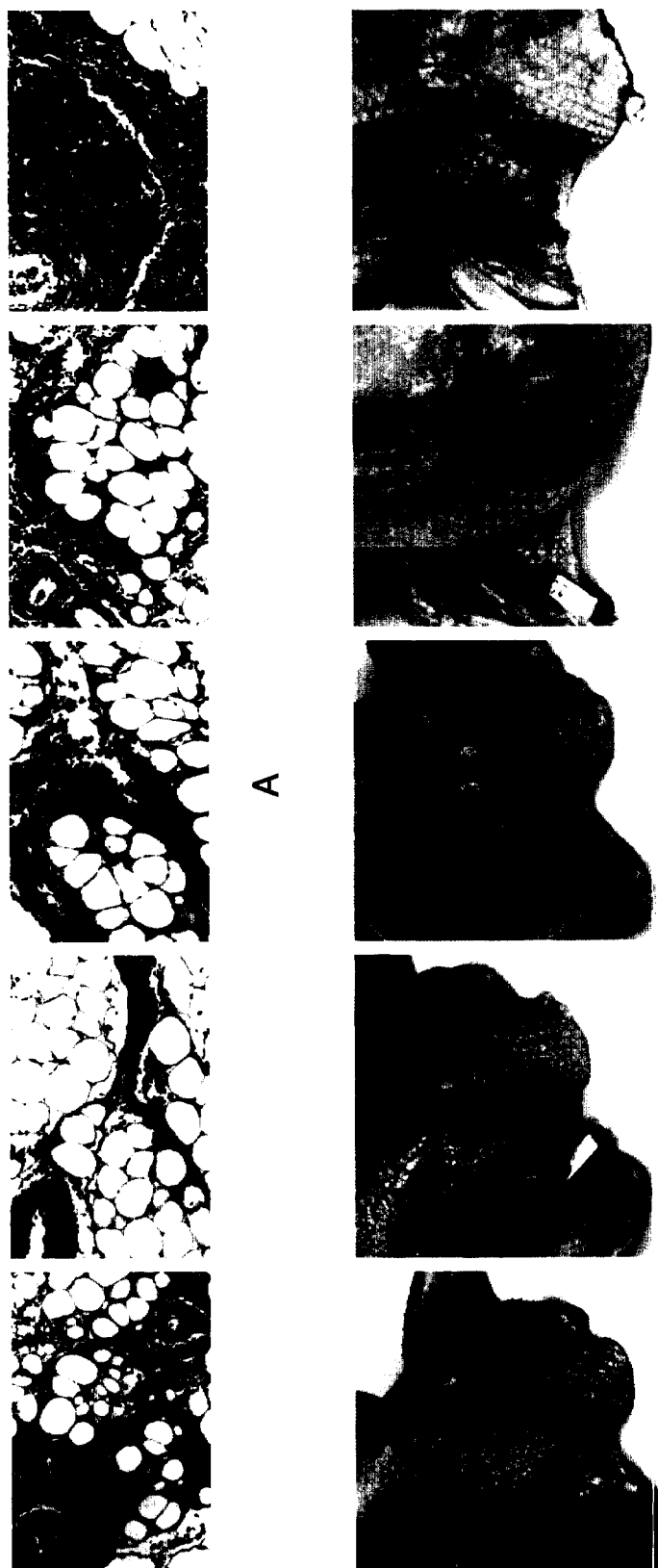


FIGURE 4. Representative photographs of bruises from 6-wk-old broilers processed at 0, 1, 6, 12, and 24 hr (left to right, respectively) after bruise:
 (A) Haematoxylin- and eosin-stained paraffin sections of the subcutis from the breast region (magnification = 106x)
 (B) Surface appearance of bruises from the breast pectoral region after scalding and picking

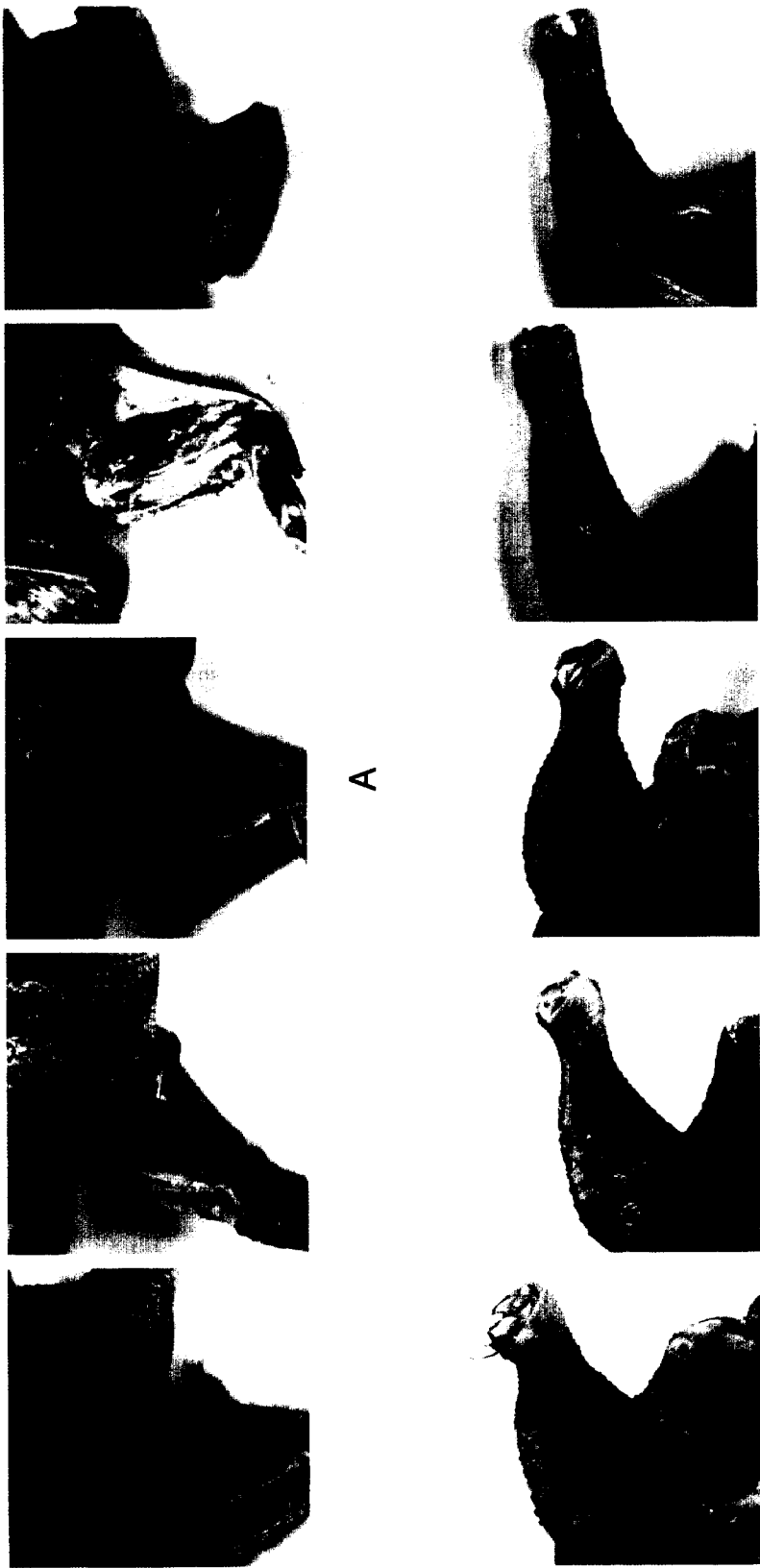


FIGURE 5. Representative photographs of bruises from 6-wk-old broilers processed at 0, 1, 6, 12, and 24 hr (left to right, respectively) after bruise:
(A) Surface appearance of bruises for the ventral wing after scalding and picking
(B) Surface appearance of bruises from the medial drum after scalding and picking

120 hr. Although these researchers did not publish photographs, objective color measurements, or histological analyses, they indicated that the color of bruises initially appeared to be red, then continued through shades of purple, green, and yellow before returning to normal. A similar color transition was found in the present study, with the bruises appearing green at 24 hr old. However, the intensity of the green varied with carcass part, possibly due to the amount of fleshing, proximity to bone, and edema in the traumatized area (Figures 4 and 5).

Histopathologically stained breast tissue samples at the various bruise ages are shown

in Figure 4, along with the corresponding breast bruises. These bruises were the least marked of any. Histopathological evaluation showed that at all bruise ages, bruises were more severe on the drums than they were on the breasts and wings. Progressive muscle degeneration was observed only in drum bruises. Maximum edema was found in bruises at a bruise age of 6 hr, which corresponds to the time period when all bruises were found to be darkest (largest ΔL). The frequency of red blood cells in the subcutis and associated muscle increased from 1 hr bruise age through 12 hr bruise age and then remained constant.

CONCLUSIONS AND APPLICATIONS

1. Breast bruises became darker, whereas wing and drum bruises became lighter with increasing bruise age.
2. Wing bruises became less red and less yellow, whereas drum bruises became more red and more yellow with increasing bruise age.
3. It is possible to estimate the age of a bruise on a broiler carcass using visual and objective color assessment.
4. Knowing the age of a bruise could be useful to the poultry industry for minimizing recurring carcass defects by identifying when the bruise occurred.

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